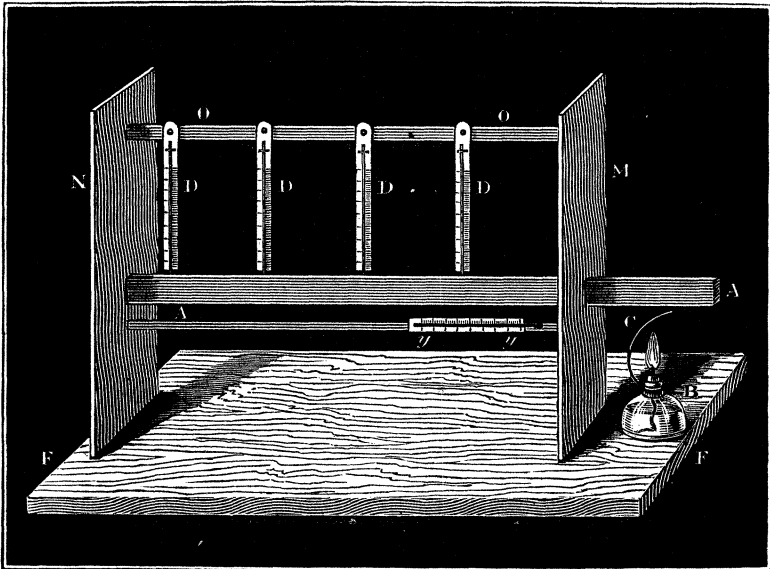


portion of the time, so that the magnitude of the "wabble" would be reduced by the friction of the 306-day tide; for we are by no means compelled to believe that that inequality of motion must always have remained as small as it is at present.

It appears to me, from these considerations, that the continents of Europe and Asia might have been elevated in very much less than 20,000 years, and yet leave no record of the fact in the present motion of the earth. Therefore, if my solution of the problem is correct, it is certain that Professor Houghton's method can give us no clue to the times which have elapsed in the geological history of the earth.

II. "Some Experiments on Conductive Properties of Ice, made in Discovery Bay, 1875-6." By Staff Surgeon R. W. COPPINGER, M.D. Communicated by Professor TYNDALL, F.R.S. Received February 21, 1878.

In attempting a series of experiments for determining the rate of conduction of heat through sea and fresh-water ice, I have endeavoured as closely as possible to follow the suggestions made by Professor Tyndall in page 34 of the "Scientific Instructions for the Arctic Expedition." With this view, I have constructed the simple appa-



ratus shown in the diagram. It consists of a wooden baseboard (F F), 29 inches in length by 9 in breadth, on which are fixed two upright

wooden battens (NM), standing 24 inches apart, and connected above by a light crosspiece (OO). In the upright battens, at 4 inches above their bases, are apertures $1\frac{1}{4}$ inches square, for the reception of the bar of ice (AA) on which the experiment is made, while a series of thermometers (DDDD) are placed 4 inches apart, secured above to the crosspiece (OO), and having their bulbs imbedded in the icebar below.

For the manufacture of ice-bars I had constructed a strong copper tube, 29 inches long by $1\frac{1}{8}$ inches in sectional area, from which on being filled with water, and exposed to a low temperature, bars of fresh or sea-water ice were obtainable. The removal of these bars from the mould was effected by the application of warm water to the outside of the tube, which, melting the surface of the ice-bar, allowed it to be extracted.

The ice-bar, being placed in position, projects, when of its full length, 5 inches beyond the upright batten (M), as shown in the figure. Below the projecting end is placed a spirit-lamp (B), fitted with a sheet-iron plate (C), curved in such a manner as to prevent the bare flame from touching the ice, and to divert the drops of melted ice from the wick of the lamp. This lamp can be so placed that its heat will bear pretty accurately on the under surface of the bar at either 2, 3, or 4 inches as desired from M. The thermometers being placed at intervals of 4 inches apart, their distances from the source of heat are respectively 6, 10, 14, and 18 inches when the lamp is 2 inches from the upright. Their bulbs are sunk in holes bored in the ice, and are packed in with powdered ice, so as to render the connexion with the bar as perfect as possible without incurring the risk of the instruments being broken.

At all low temperatures the instruments used were Hick's spirit thermometers. Although these instruments were supplied to the ship as of good reputation, their errors at temperatures below -10° differed so much in each instrument for every few degrees of the scale, that I found it best in recording the rate of heat-flow along the ice-bar to take the temperature actually indicated by each thermometer *uncorrected*, and to note the *range* of temperature in each, assuming that its error for every two or three degrees, at all events, was uniform.

In the earlier experiments I noted the temperature every 5 minutes for about 2 hours, beginning 5 minutes after the lamp had been lighted; but finding that interval too small to show any decided difference in temperature, I had recourse to 10-minutely, and ultimately to 15-minutely intervals. The entire duration of each experiment was limited to one hour, as by that time so much of the projecting end of the bar had melted away as to lessen the influence of the lamp upon it.

In order to determine whether the rise in temperature indicated by the thermometers might be to any extent due to radiation of heat from the lamp rather than to conduction through the ice-bar, the thermo-

meter YY was placed on the inner side of the upright M, having its bulb exposed to the air and 5 inches distant from the lamp. Having found from experiments I and II that a certain amount of radiation really existed, a broad screen, composed of layers of lint and pasteboard, was placed against the outer side of the upright M, and perforated, so as to closely encircle the bar in its passage through. This screen was used in III and subsequent experiments.

In order to be free from draughts, and yet to be in a place of low and pretty uniform temperature, the observations were made in a closed-in ice-building on the floe (that which was used as a theatre), and the temperatures of the external air and of the air inside the building were on each occasion noted. It was found that whenever the temperature in the open air was below -20° F., the temperature inside the building was about 10° warmer; this difference being accounted for by the heat conveyed through the floe from the sea-water beneath.

From a mean of five experiments on fresh-water ice it appears that in one hour from the time when heat was applied, the temperatures at the distances of 6, 10, 14, and 18 inches from the source of heat had risen $4^{\circ}45$, $1^{\circ}78$, $1^{\circ}30$, and $0^{\circ}25$, respectively. This result furnishes a rough method of estimating the absolute rate of conduction. It would have been more satisfactory if in all cases the observations could have been continued until the thermometers indicated fixed temperatures, but this was impracticable from the thawing of the end of the ice-bar; and if but a very moderate heat had been applied, the changes in temperature would have been hardly appreciable. In most cases but little change in temperature took place after the hour had elapsed, and in the case of experiment VIII, when a series of observations extending over two hours was carried out, the thermometer indicated no material change in temperature throughout the second hour.

Table VI gives the results of a series of observations upon a bar of sea-water ice, the rise in temperature being respectively 4° , 2° , $1^{\circ}5$, and $1^{\circ}5$.

It will be seen that in Tables I, II, and III, the temperatures indicated by thermometer YY are given, and that in I and II its ranges of temperatures are respectively 4° and $2^{\circ}5$. In III the screen to prevent radiation was used, and every precaution was taken that the temperature of the ice-house might be uniform throughout the course of the experiment. In this case thermometer YY shows a rise in first hour of only $0^{\circ}25$. To exhibit this more clearly Table VIII (the first half of which is only a repetition of Table III) is given, when the results of observations extending over two consecutive hours are recorded; and from which it appears that the ice thermometers indicated almost fixed temperatures from the end of the first hour. The temperature of

the house varied but half a degree during the course of the experiment, and the thermometer YY showed a rise of only $0^{\circ}75$, which is small when compared with its short distance (5 inches) from the flame. The results, therefore, afforded by Table VIII may be considered highly satisfactory.

I refrain from making any general observations or drawing any special conclusions as to the subject of this paper, but simply submit the above few observations with the hope that in abler hands than mine, the facts which they contain may be made to add something to our knowledge of the conductive properties of ice.

I. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

Temperature of outer air = -37° . January 3, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature in ice house.	Ther. Y.Y.
hours min.						
9 8	$-26^{\circ}75$	$-27^{\circ}75$	$-24^{\circ}00$	$-23^{\circ}00$	-24°	-27°
9 23	$-26^{\circ}00$	$-27^{\circ}00$	$-23^{\circ}5$	$-23^{\circ}00$	-23	-25
9 38	$-24^{\circ}5$	$-26^{\circ}25$	$-23^{\circ}00$	$-23^{\circ}00$	-23	$-24^{\circ}5$
9 53	$-22^{\circ}5$	$-25^{\circ}25$	$-22^{\circ}5$	$-22^{\circ}00$	-22	$-23^{\circ}5$
10 8	$-21^{\circ}5$	$-24^{\circ}75$	$-22^{\circ}00$	$-21^{\circ}5$	-22	-23
Range	5.25	3.00	2.00	1.5	2	4

II. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

December 28, 1875.

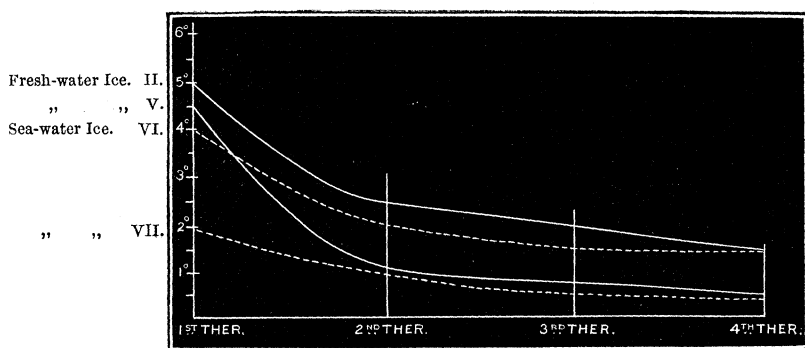
Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature in house.	Ther. Y.Y.
hours min.						
5 55	$-24^{\circ}5$	$-25^{\circ}25$	-22°	$-21^{\circ}25$	$-25^{\circ}25$	$-24^{\circ}5$
6 10	$-23^{\circ}5$	-24	$-21^{\circ}5$	-21	..	$-23^{\circ}5$
6 25	-22	-24	$-20^{\circ}75$	$-20^{\circ}25$	..	-23
6 40	-21	-23	$-20^{\circ}5$	$-19^{\circ}75$	..	-23
6 55	$-19^{\circ}5$	$-22^{\circ}75$	-20	$-19^{\circ}75$	$-25^{\circ}25$	-22
Range	5	2.5	2	1.5	0.0	2.5

III. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

Temperature of outer air = -43° . January 7, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature in house.	Ther. Y.Y.	Remarks.
hrs. min.							
9 46	-23°	-24°	-21°	-20°	-21°	-23°	Screen used to prevent radiation.
10 1	$-22 \cdot 25$	-24	$-20 \cdot 75$	-20	$-20 \cdot 75$	-22	
10 16	-21	$-23 \cdot 5$	$-20 \cdot 5$	$-19 \cdot 90$	$-20 \cdot 5$	-22	
10 31	$-20 \cdot 1$	$-23 \cdot 25$	$-20 \cdot 5$	-20	$-20 \cdot 75$	-22	
10 46	$-19 \cdot 75$	-23	$-20 \cdot 25$	-20	$-20 \cdot 5$	$-22 \cdot 75$	
Range..	$3 \cdot 25$	$1 \cdot 0$	$0 \cdot 75$	$0 \cdot 0$	$0 \cdot 5$	$0 \cdot 25$	

Curve of relative Conductivities.



IV. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

Temperature of outer air = -34° . January 11, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature of house.
hours minutes					
12 13	$-19^{\circ} 25$	-16°	-16°	$-18^{\circ} 5$	-17°
12 28	$-18 \cdot 25$	$-17 \cdot 75$	$-15 \cdot 25$	-18	-16
12 43	-17	$-15 \cdot 1$	-15	$-17 \cdot 5$	$-15 \cdot 75$
12 58	-16	$-14 \cdot 75$	-15	$-17 \cdot 5$	$-15 \cdot 25$
1 13	-15	$-14 \cdot 75$	-15	$-17 \cdot 25$	-15
Range	$4 \cdot 25$	$1 \cdot 25$	$1 \cdot 00$	$1 \cdot 25$	2

V. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

Temperature of outer air = -46° . February 10, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature of house.
hours minutes					
6 50	-22°	$-20^{\circ}75$	$-21^{\circ}5$	$-21^{\circ}5$	$-21^{\circ}5$
6 5	$-21^{\circ}5$	$-20^{\circ}5$	$-21^{\circ}25$	$-21^{\circ}25$	$-21^{\circ}1$
6 20	-20	-20	-21	-21	-21
6 35	$-18^{\circ}25$	-20	-21	-21	-21
6 50	$-17^{\circ}5$	$-19^{\circ}16$	$-20^{\circ}75$	-21	-21
Range	4.5	1.15	0.75	0.5	0.5

VI. Sea-water Ice. Flame 6 inches from nearest Thermometer.

March 13, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature of house.
hours minutes					
11 7	-25°	-24°	$-24^{\circ}5$	$-24^{\circ}5$	$-25^{\circ}5$
11 22	$-24^{\circ}25$	$-23^{\circ}25$	-24	-24	$-24^{\circ}75$
11 37	$-23^{\circ}1$	$-22^{\circ}8$	$-23^{\circ}75$	$-23^{\circ}75$	-24
11 52	-22	$-22^{\circ}1$	$-23^{\circ}1$	$-23^{\circ}1$	$-23^{\circ}5$
12 7	-21	-22	-23	-23	$-23^{\circ}25$
Range	4	2	1.5	1.5	2.25

VII. Sea-water Ice. Flame 8 inches from nearest Thermometer.

Temperature of outer air = -55° . February 29, 1876.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature of house.
hours minutes					
6 15	-22°	-21°	$-21^{\circ}5$	$-21^{\circ}5$	-20°
6 30	$-21^{\circ}75$	$-20^{\circ}5$	$-21^{\circ}4$	$-21^{\circ}5$	-20
6 45	-21	$-20^{\circ}25$	$-21^{\circ}1$	$-21^{\circ}2$	-20
7 0	$-20^{\circ}75$	$-20^{\circ}1$	-21	$-21^{\circ}1$	$-20^{\circ}5$
7 15	$-20^{\circ}1$	-20	-21	$-21^{\circ}1$	$-20^{\circ}5$
Range	1.9	1.0	0.5	0.4	—

VIII. Fresh-water Ice. Flame 6 inches from nearest Thermometer.

Temperature of outer air = -37° . January 3, 1876.

Heat applied continuously for two hours.

Time.	Ther. 1.	Ther. 2.	Ther. 3.	Ther. 4.	Temperature of ice house.	Ther. Y.Y.
hours min.						
9 46	-23°	-24°	-21°	-20°	-21°	-23°
10 1	$-22\cdot25$	-24	$-20\cdot75$	-20	$-20\cdot75$	-22
10 16	-21	$-23\cdot5$	$-20\cdot5$	$-19\cdot9$	$-20\cdot5$	-22
10 31	$-20\cdot1$	$-23\cdot25$	$-20\cdot5$	-20	$-20\cdot75$	-22
10 46	$-19\cdot75$	-23	$-20\cdot25$	-20	$-20\cdot5$	$-22\cdot75$
11 1	$-19\cdot25$	-23	$-20\cdot25$	-20	$-20\cdot5$	-23
11 16	$-19\cdot5$	-23	$-20\cdot5$	-20	-21	-23
11 31	$-19\cdot25$	$-23\cdot1$	$-20\cdot5$	$-20\cdot25$	$-20\cdot9$	$-22\cdot5$
11 46	-19	-23	$-20\cdot25$	-20	$-20\cdot75$	$-22\cdot25$
Range in 1 hr.	$3\cdot25$	$1\cdot0$	$0\cdot75$	0	$0\cdot5$	$0\cdot25$
Range in 2 hr.	4	1	$0\cdot75$	0	$0\cdot25$	$0\cdot75$

III. "On the Function of the Sides of the Vessel in maintaining the State of Supersaturation." By CHARLES TOMLINSON, F.R.S. Received February 21, 1878.

Before any consistent theory can be framed of all the phenomena of supersaturated saline solutions, it is necessary to determine whether the sides of the vessel bear any, and what part, in maintaining the state of supersaturation.

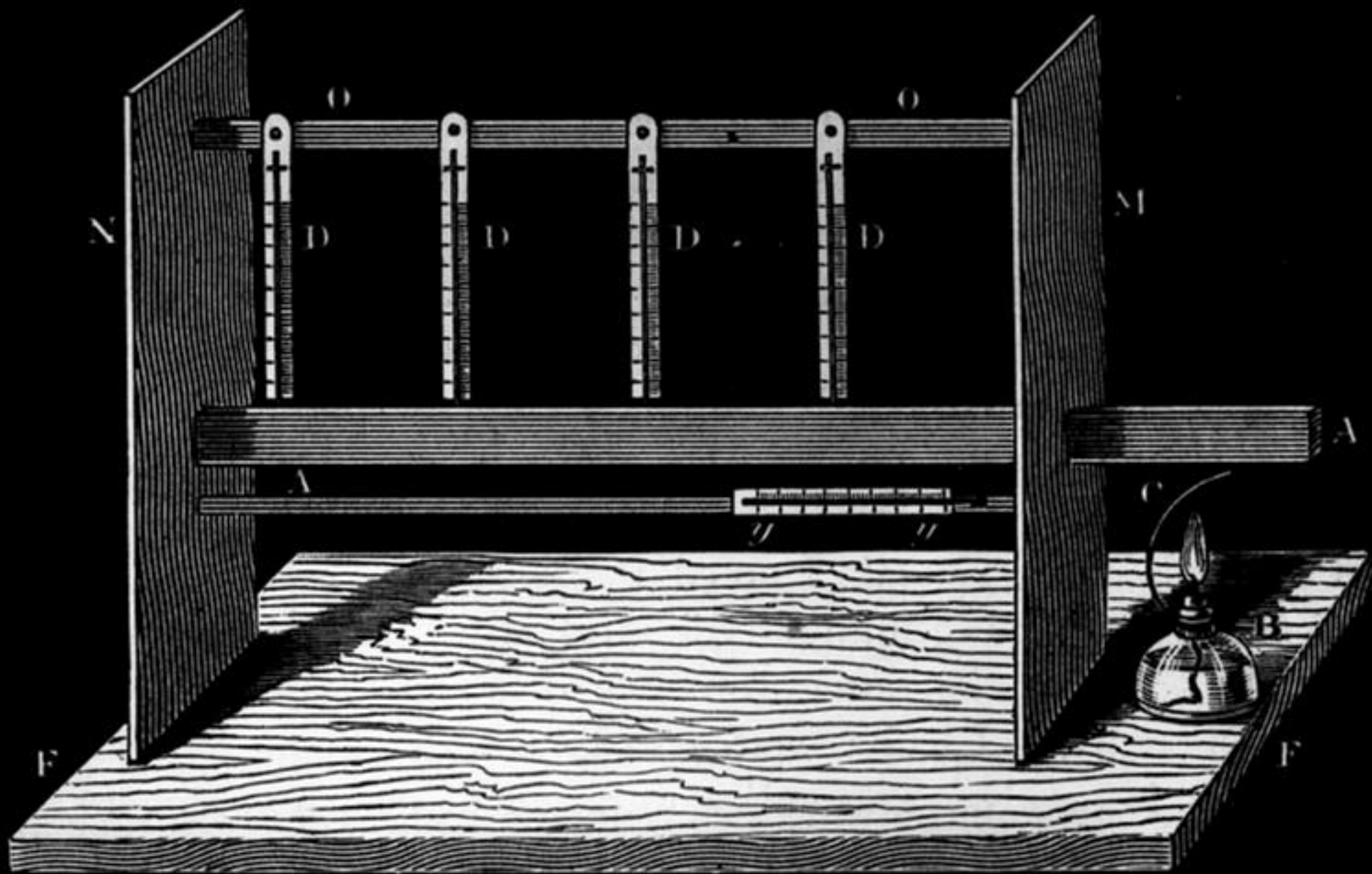
It is remarkable that among the multitude of memoirs and papers that have been published on the subject of supersaturation generally, and of special phenomena in particular, my reading should not have made me acquainted with any special experimental researches conducted with the view of determining the point in question.

In 1819, Gay-Lussac* seeing how easily a supersaturated solution of sodic carbonate can be made to solidify, by merely shaking the vessel, expressed his opinion that the state of supersaturation depends, not on a chemical, but a purely mechanical force. "We cannot," he says, "fix the point at which supersaturation ends, since it is entirely accidental in each experiment, depending, as it does, on the nature of the vessel, its polish, its conducting power, and the agitation of the air."

In 1851 Lamy† arrived at the conclusion that the form, thickness, and nature of the vessel, and the quantity of solution contained therein, have no influence on the state of supersaturation.

* Ann. de Ch. et Phy., 2e Serie, xi, 303.

† Comptes Rendus.



Curve of relative Conductivities.

Fresh-water Ice. II.
 " " V.
 Sea-water Ice. VI.
 " " VII.

